

Intelligent Reports for Group Decision Support Systems

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Abstract. The topic of Group Decision Support Systems (GDSS) is a not a recent one. In fact, it has been studied for the last three decades. In this work, we deal with the topic of Intelligent Reports in GDSS' context. A defective interaction between the system and the decision-maker may lead to the complete failure of the GDSS. However, the study on how and which kind of information should be exposed to decision-makers is almost non-existent. Therefore, it is important to create reports adapted to the specific necessities of each decision-maker so that each one can acknowledge the advantage to use the system and feel motivated to do so. We believe that in this work, we approach important points that require special attention when developing Intelligent Reports. We navigate through all the important factors that affect decision-makers while making a decision. We detail each point and link them to all related questions and to which kind of structure an Intelligent Report should have in order to not compromise the success of the GDSS.

Keywords. Intelligent Reports, Group Decision Support Systems, Decision-Making, Multi Agent Systems

1. Introduction

Over the last years, organizational decision-making process stopped involving just one person (usually one manager) and now usually involves a group of people (for instance, an entire team) [1]. Group decision-making is a process in which a group of people, called participants, analyse a set of variables, consider and evaluate alternatives and select one or more solutions. The number of participants involved in the process can vary and they can either be at the same place and at the same time or geographically dispersed at different times [2]. When the decision-making process is performed in group, the chance to detect a problem is higher, and subsequently they can work together to find a solution for that problem. This turns group decision-making into a more effective and fast process [2].

The Group Decision Support Systems (GDSS) have evolved since they first appeared [3]. They evolved thanks to new technology achievements done in the latest decades and the need to improve the effectiveness of group decisions. These systems

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have been used to aid groups in their decision-making tasks. Usually they use computers, communications and decision methodologies to support users in the decision-making process. The evolution of the internet improved GDSS and users can now participate in meetings while being geographically dispersed (also known as internet-based GDSS) [4]. However, a major problem appeared when group members started dispersing in space and time. In response to that, a new concept emerged, known as Ubiquitous Group Decision Support Systems (UbiGDSS) that allows decision-makers to contribute with a possible solution to a certain problem from anywhere, at any time and through (almost) any kind of device [5].

The concept of ubiquitous computing was first introduced by Mark Weiser in 1980s [6]. It is clear that an interaction between decision-makers and an UbiGDSS is essential. However, there are almost no studies on how that interaction should be done, what type of information should be exposed to decision-makers and in which kind of format. Some authors believe the level of acceptance of the Decision Support System is directly related to the difference between the user and the system forecasts. Users accept system suggestions if the given explanations are more effective and persuasive [7]. There are still some questions regarding usability and interface design that should be considered or the entire success of the system might be compromised [8]. In addition, it is important to expose information according to each specific decision-maker and his interests [9].

In this work, we study the points that must be considered when creating Intelligent Reports(IR) for UbiGDSS. We relate those points to the creation of IR that do not compromise the success of the UbiGDSS. Therefore, the main goal of this work is to share the knowledge that is necessary to develop IR. These reports let decision-maker see the advantage to use the system and motivate him to do so. Another purpose of this work is to alert other researchers to the lack of studies in this area that has been forgotten but still is essential for the success of GDSS.

The rest of the paper is organized as follows: in the Section 2 introduce the topic of IR in the context of GDSS. In Section 3, we present which methods should be used to produce IR that do not compromise the success of a GDSS. Besides this, we detail each point that should be considered supported by existing studies in literature. Finally, some conclusions are taken in Section 4, along with the work to be done hereafter.

2. Intelligent Reports

When we look at literature related to GDSS or even Decision Support Systems in general, we find many works that propose: architectures, problem-specific models, frameworks, etc [10–12]. Besides that, we still learn which kind of information should be presented to decision-makers and through which kind of format [13]. However, if the existing approaches make sense in GDSS of the type face-to-face, for the case of UbiGDSS those same approaches stop making sense. A group decision-making process is continuous as it involves several iterations, as well as interactions between decision-makers. It is clear that there is a necessity for the system to interact with the decision-maker to achieve the two objectives: report data and stimulate participation. Interaction is essential for the success of an application. It is then relevant to talk about how, and what should be the solution for the existing interactions between the system and decision-makers in an UbiGDSS.

Reports are used in all areas and it is impossible for us to say when (historically) they were first used. We know (by the common sense) that a report is an artifact used to clarify a specific audience, about a specific subject. This means that a report should present only adequate information, in a structured way and be very clear. A report should be (to a targeted audience) clear and easy to follow [14]. It makes sense that whenever a decision-maker interacts with an UbiGDSS he can access a report and obtain the information he needs to better understand the decision-making process. Therefore, we believe that it makes sense to think in IR. An IR must be a report adapted and generated specifically for each decision-maker. There are several “things” in literature that have become intelligent: Intelligent Tutoring Systems [15], Intelligent Systems [16], Intelligent Interfaces [17], Intelligent Machines [18], etc.

It almost surprising to notice the lack of work done under this topic when GDSS have been studied for over three decades. Similarly to intelligent systems, an Intelligent Report should be generated specifically for each decision-maker. It should also have the capacity to understand the necessities and the interests of the decision-maker and adapt the information to that context. It can be built (for instance) through an intelligent agent that seeks the most relevant information for a certain decision-maker and presents it in the correct and ideal format.

3. Methods

We can find in literature a great amount of work related to GDSS. Automatic negotiation mechanisms related to decision-making are also widely explored [19–22]. In addition, there is a recognized benefit (by researchers) to use such type of systems in group decision-making. However, the lack of success and imposition of such systems on the market is undeniable. The introduction of IR under the GDSS aims to bring decision-makers closer and allow researchers to use this knowledge to design this type of systems. This way IR can meet the interests of the decision-makers without compromising the success of an entire system (by not considering points that are essential for this type of context).

Group decision-making is one of the most used formats to make decisions. Moreover, there are also several recognized advantages in decisions made in group compared to decisions made by individuals, such as: to improve the quality of the decision, to share workloads, to gain support among stakeholders, to train less experienced group members and due to the majority of organograms existing nowadays [2, 23]. However, these advantages do not exist only because several decision-makers make the decision. For these advantages to exist, it is essential to create conditions for groups to perform certain tasks, such as generating ideas and solutions through group interaction [24]. It is considered that with the group decision-making process, members will enhance the ability to learn and stimulate their cognition level [25]. This means that IR are a vital component to provide information to decision-makers, so that interactions and the process can be successful and consequently the UbiGDSS as well.

To generate something that we can call of an Intelligent Report, we know that (by analogy) according to literature it should adapt to the specific needs of decision-makers and be a component that can motivate and capture their interest in the process. Along with the user interface to re/configure the problem (as suggested in literature [26]), the

reports are the component in which decision-makers will interact with most of the time. It is crucial that a report can allow a decision-maker to understand the advantage to use the system and motivate him to do so. Before proceeding with this study it is relevant to look at the difference existing between the information reported by a GDSS and what can be obtained by using a Business Intelligence (BI) system.

Unlike what happens with GDSS, BI systems have been far more successful in business communities despite the fact they are still more recent [27]. Similarly to GDSS, BI software main goal is to support the decision-making process and allow making higher quality and faster decisions [28]. However, the kind of data used by BI technologies (even when operating with structured and semi-structured data) are usually related to business while GDSS use information regarding the opinion and preferences of decision-makers [29]. We can say that BI has always been looked at in a more objective and practical way, which may be the reason for its success compared to GDSS. We verified that many proposed works under the topic of BI, are more practical and focused on the benefits for the final user [30–32]. On the other hand, despite the scientific value of works written under the topic of GDSS, their adaptation to the real world and how the final user can take advantage of such proposals seems to be very complex and distant. With that said, if the GDSS users have access to a report, they can see information that is relevant and easy to understand, and they can quickly have the perception of what is happening in the decision-making process. We think this way it is possible to increase the acceptance of these systems and increase decision-makers' contribution in the group decision-making process.

This study has been done based on existing investigation about the necessities and interests of decision-makers. With that being said, in this work the decision-maker is seen as the main element in the equation. It is known that the quality of the information provided to the decision-maker is proportional to the quality of the decision [33]. Besides this, an important conclusion withdrawn from O'Reilly work is that decision-makers prefer information with more accessibility rather than quality. This happens due to the associated cost (both social and economic) to find higher quality information [33]. O'Reilly mentions that these evidences have never been verified before in "laboratory tests" where decision-makers are more concerned with factors related to the quality of the decision. However, in real scenarios, decision-makers deal with situations not verified in experimental contexts such as: stress, anxiety, pressure, etc. This allows us to conclude that the information that is chosen and displayed to decision-makers will affect the decision either positively or negatively. In this work we have considered three factors that will be the base to build the type of report that should be given to a decision-maker:

- Expertise Level: An Intelligent Report should adapt to the expertise level of each decision-maker [34]. This means that the complexity of the information that is reported to a decision-maker should be in accordance with the capacities and knowledge of that decision-maker. More complex information can be provided to a decision-maker with a higher expertise level [35]. More detailed data can be presented to this decision-maker since he will be able to understand it [35]. On the other hand, information that is easier to understand should be presented to a decision-maker with a low expertise level [35]. Both decision-makers with high or low expertise levels should be allowed to access all information details. However, these details should not be part of the "main" report and should only be available if the decision-maker intends to navigate to them;

- **Time:** the time needed for a decision-maker to analyse a problem should be considered when creating an Intelligent Report [36]. This factor affects the level of detail that should be considered for the report. In this case time corresponds to the availability or dedication and the effort rate given by a decision-maker towards a certain decision-making process [37]. When the time is short, the information should be more specific and should be oriented mostly to the main interests of the decision-maker (see the next presented factor). When the time or the effort rate given increases, reports should still follow the interests of the decision-maker but can be structured in different sections and cover other topics not strictly related to the main interests of the decision-maker;
- **Interest:** Figuring the real interests of a decision-maker during the decision-making process is the most important factor that should be considered when creating an Intelligent Report [38, 39]. The interest is very variable and is always related to the type of model/system of the GDSS that is being used. Interests can be related with the topic, process or other objectives [40]. For instance, the decision-maker may be interested in the objectives of other decision-makers and in that case the type of information that appears in the Intelligent Report should be more focused on the objectives of the others [38]. Another example could be when a decision-maker does not have any sort of interest towards the decision-making process. These three factors should work in combination in the Intelligent Report. For example, a decision-maker that has a huge interest in the problem, but still does not know much about the topic being discussed, should be able to view a large amount of detailed information but with a low level of complexity. Another example is a decision-maker that considers three other decision-makers as experts in a certain topic. In this case it could make sense to show him information related to the opinions or preferences of these three decision-makers and how those opinions (and preferences) affect the general opinion of the group.

Table 1 shows the relation existing between Expertise and Time factors.

Table 1. The relationship between Expertise and Time factors

		Expertise	
		Low	High
Time	Low	Low Detail, Low Complexity	Low Detail, High Complexity
	High	High Detail, Low Complexity	High Detail, High Complexity

Besides these three factors, we have grouped together several themes (according to the literature) that are related to this work in topics and subtopics as can be seen in Table 2. These themes are all important since they affect the interaction between the system and the decision-maker by using and Intelligent Report. The complexity of an Intelligent Report should vary depending on the amount of topics/subtopics that are considered and how they are considered.

3.1. Data

We know that the main objective of a report is to report information. However, which kind of information? In which format? According to literature [13] “statistical information presented as simple frequencies is viewed as being clearer and easier to understand

Table 2. Several themes that should be considered in the development of Intelligent Reports

Topics	Subtopics
Data	Kind of information, format of information, complexity of information [13, 41–44]
Affective Issues	Emotional issues, anxiety, stress, sadness [42, 45, 46]
Relationships	Credibility, seniority, hierarchy, reputation, expertise, friendship [47–49]
Interpersonal Conflicts	Interest in the decision process, personality, behaviour, strategy [40, 50–53]
Usability	User interface, interaction, interface, appealing, graphics, understanding [8, 54, 55]

than the same information in other types of representational formats, and information presented as single-event probabilities is particularly difficult to understand”. Besides this, it should transform the data analysed in information that the decision-maker cannot obtain. We know that providing information that is not achievable by the human mind is considered beneficial [41]. It is important that the amount of provided information is adequate. Too much information may “suffocate” decision-makers, while much little information may lead to decision-makers losing interest in the system [42]. Another important point is the credibility of the information. The fact that a decision-maker may consider the information to be credible allows him to accept other points of view more easily and even accept other solutions [43]. When the information is anonymous the decision-maker will consider it to be less credible [43]. Still regarding to information, it has been proved that the decrease of effort offered by the system so that the decision-maker can make a decision is more important than the amount of information that can be provided [44].

3.2. *Affective Issues*

Affective issues have a great impact to decision-makers. There are several evidences that show how these issues can affect decision-makers. For example, it was verified that sad participants prefer to choose a high-risk/high-reward option, whereas anxious participants tend to choose the low-risk/low-reward option [45]. It has been proved that immediate emotions felt during the decision-making process change the decision maker’s perceptions of probabilities or outcomes or alter the quality and quantity of processing of decision-relevant cues. Besides this, these immediate emotions can affect behaviour directly and as they intensify, they progressively take control of decision making and override rational decision making [46]. Researchers stated that relieving stress helps to improve the efficiency of decision-makers [42]. These factors demonstrate the impact and the importance of an Intelligent Report that is capable to perceive this kind of aspects and how it will result in higher quality group decisions (fundamentally in ubiquitous contexts).

3.3. *Relationships*

Relationships are also an important factor in the decision-making process. For example, researchers have proved that the impact of the external status in decision-makers is lower when groups communicate using a mechanism such as electronic mail instead of face-to-face communication [47]. Another important point is related with the existence of internal conflict constraints that restrain the possibility for truthful information exchange [48]

and making the entire process very transparent to decision-makers will result in an increase of motivation and to share true information [48]. Other researchers concluded that groups with a very active leader exchange more information [49] and that may be a good reason to create IR directed towards leaders. These reports provide them information that can be used to share knowledge and that will motivate other decision-makers to be more participative throughout the decision-making process.

3.4. Interpersonal Conflicts

Another factor very discussed in literature is related with how the decision-maker stands besides others and the process. This position can vary for several reasons which are not entirely related such as: strategic questions [50], type of personality of the decision-maker [51] and the interest in the decision-making process which affects his behavior [40]. Rahim and Magner [38] have defined in their work the existence of five conflict styles (Dominating, Integrating, Avoiding, Obliging and Compromising) which act according to the dimensions of Concern for Self and Concern for Others. Martinho et al. [52], have made an adaptation of Rahim and Magner's work to the context of GDSS and defined the same 5 conflict styles (which they refer as behaviour styles) and that act according to the dimensions of Concern for Self, Concern for Others, Activity Level and Resistance to Change. There are also other researchers such as Santos et al. which have proposed models for GDSS using agents that represent decision-makers and that are modeled with different types of personality in order to make a more realistic representation of the decision-maker. According to literature we verified that there are two main distinct points related to the definition of interpersonal relationships (in the context of the topic discussed in this work): personality related questions, i. e., the personality of the decision-maker in each specific situation (his identity) [53] and strategic questions [38], which can vary according to each situation the decision-maker faces. This variation affects his behaviour.

3.5. Usability

Usability describes the nature of human-computer interaction [56]. The interaction component is essential for the decision-maker to accept the system. The usability level of an application is one of the main factors which affect user satisfaction [54]. Looking at the topic discussed in this work and doing some analogy, it is possible to verify that if end-users believe the system will improve their performance and productivity they will feel more satisfied while using it [8]. Besides, nowadays it is known that there is a direct relationship between architectural decisions and usability requirements [55]. All these details confirm the impact of usability aspects in the success of a GDSS, as well as in the success of any other kind of application. This way, usability should be considered since the planning phase.

4. Conclusions and Future Work

GDSS have become an important topic of study in the past three decades. Their advantages and benefits are widely acknowledged by everyone, especially when supporting decision-makers that cannot gather at the same place and time. However, we cannot say

that GDSS have been well received in most organizations. Although there is no study that specifies the reasons of that failure, it is strange to notice how there is very few work done on reports which is something that is very important to support the decision-making. After all, it is thanks to these reports that GDSS can interact with the decision-maker and report information. Reports are the one side of the face of the GDSS to the decision-maker. It is thanks (in part) to reports that decision-makers will be motivated and focused in the decision-making process. In this work, we (considering the literature) almost introduce the concept of IR in the topic of GDSS.

We have done a wide study in literature in order to find every point that affects the moment when we make a decision. It was important to identify what information should be used to make decisions with confidence. We have related that information with the topic that is discussed in this work and we have grouped all the information found in five topics: data, affective issues, relationships, interpersonal conflict and user interface. Besides this, we analysed each one of these topics with more detail and referred to the influence of some questions in the decision-making process. We figured that an IR can compromise the success of a GDSS. We concluded that for a GDSS to be successful it is essential to pay attention to the way the interaction between the system and the decision-makers is done, while respecting their needs and preferences.

As future work, we intend to still work in the topic of IR. In first place, we want to design a template for how the structure of an Intelligent Report should be. This task intends to define the organization and the arrangement of the information including the decision-maker interests in the process. In second place, we want to work in a component where an agent represents the decision-maker, which is responsible to build the IR. Therefore, the idea is to make the agent capable of understanding inconsistencies in the decision-maker preferences and provide him detailed data related to those inconsistencies. In the last place, we intend to develop a component that can understand how certain kind of information emotionally affects the decision-maker. We aim to use this knowledge to show some information in a perspective that keeps the decision-maker with high level of motivation and interest in the decision process.

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